data. These charts comprise the twelve charts of isotherms for the twelve months, and one chart of annual isotherms. They are most noteworthy and interesting, and will throw much light on meteorological and climatological conditions in eastern Asia.

## THE VARIATION IN MINIMUM TEMPERATURES ON STILL, CLEAR NIGHTS WITHIN THE CONFINES OF A VILLAGE.

By Prof. WILLIS I. MILHAM, Ph. D., Williamstown, Mass. Dated August 4, 1905.

The present investigation was suggested by the reports of extremely low temperatures from different parts of a village, while a registering minimum thermometer, exposed in a regular thermometer shelter, gave much higher readings. The purpose of the investigation was to determine, among other things, the amount of the total variation, the influences that determine the amount of the variation, and the regularity with which a certain station is either colder or warmer than other stations. The observations were made in the village of Williamstown, the seat of Williams College, which is located among the Berkshire Hills of western Massachusetts. The village is situated in the middle of a saucer-like depression about three miles in diameter, surrounded by fairly high mountains, the highest peaks of which range from about 1200 feet to 3505 feet (Greylock Mountain). There are two main valleys leading into this depression, one from the east and one from the south. The outlet through which the Hoosic River flows is to the northwest. The village proper is about one and one half miles long and three quarters of a mile wide, and is situated on three small knolls in the middle of this depression; it consists of detached houses, surrounded by ample lawns and gardens, and the streets are wide. The accompanying map, fig. 1, shows the streets and water courses; the contour lines, drawn every ten feet, give the elevation above mean sea level.

The thermometers used in this experiment were exposed at ten different stations in the village. These stations are numbered from one to ten, and each location is indicated on the accompanying map. A scale of distances and the true north and south direction have been added, so that in every case the elevation, the direction of the slope, the steepness of the slope, and the distance from running water can be determined from the map. It will be seen that Williamstown has a very diversified surface, consisting of fairly level areas, marked valleys, plenty of running water, and differences of elevation amounting to 120 feet. It is, therefore, well suited to the investigation of this problem.

The thermometers used were self-registering, minimum, alcohol thermometers of the regular Weather Bureau type, made by H. J. Green, of Brooklyn, N. Y. Each one was mounted on an unpainted pine board, about eighteen inches long and seven inches wide, exposed in the open, without a shelter of any kind, exactly five and one half feet from the surface of the ground, on the northwest side of a post or small tree at least fifteen feet from the nearest building, and always with a clear space of at least forty feet on the northwest side. The ground was covered with snow during the whole experiment, so that the surface under each thermometer was the same. Absolute uniformity in every particular was aimed at in exposing the thermometers.

The variations treated in this article are not due to inaccuracies in the thermometers, as the following precautions were taken:

(1) All the thermometers were wrapped up together in cloth and placed in a room where the temperature was nearly constant. At the end of several hours every thermometer indicated the same temperature within one or two tenths of a degree. This was done at the beginning and end of the investigation. (2) The thermometers were all read on several different occasions during high winds, while the temperature was changing slowly and the sky was covered with clouds. The readings always differed from the mean of all readings by less than one degree. (3) The thermometers were frequently changed from station to station during the investigation.

The observations were made during the winter of 1904–5 and are given in full for 36 nights in the accompanying Table 1. Observations were always taken when the temperature fell to zero or below at any point in Williamstown; also several additional sets when the temperature fell nearly to zero. The table thus contains observations for practically every night when there was a decidedly low temperature. A few observations are missing. Two thermometers were not put into commission at the beginning of the investigation and the other observations were lost for reasons which are of no interest here. These missing observations, however, in no way influence the conclusions which are drawn. Extreme care was used in setting the thermometers and making the readings and every effort was made to avoid all errors that might result from causes such as the jarring of the thermometer by the wind, careless setting or reading, tampering with instruments by unauthorized persons, etc. The first column of the table contains the date of observation. Even if the minimum occurred before midnight, the date given is always that of the following morning, when the readings of the thermometer were made.

Williams College is a cooperative station of the U. S. Weather Bureau and its shelter for the thermometers is of the form advocated by the Weather Bureau and is placed on the north side of an unheated building. There is an ample air space between the building and the shelter, and the instruments are five and one-half feet above the ground. The column under "Station" headed "A" contains the observations of minimum temperature made in this thermometer shelter. Station 1 was twenty feet north of this shelter and thus serves as a connecting link between observations made in a regular thermometer shelter and observations made in the open without a shelter as is the case with the ten stations. The columns under "Stations" and numbered 1 to 10 contain the observations made at ten stations whose positions are indicated on the map. The column headed "B" contains the observations made on a registering, minimum thermometer exposed on a small iron post of a piazza on the north side of a house. The thermometer was five and one-half feet above the floor of the piazza, six feet from the house and twenty feet southeast of station 8. These observations are added as this is a favorite way among people living in a village of exposing ordinary thermometers. The column headed "Total variation" gives the difference between the higher and lower temperatures observed at the ten stations on the night in question. The next column gives the characteristics of the night as regards the wind. The letters indicate the direction of the wind at 10:30 p. m. and it will be seen that it was from the northwest in every case. If the wind changed during the night this is indicated by a [*] and in every case it changed to either the east or southeast. The two numbers separated by a dash give the estimated wind velocity in miles per hour at 10:30 p. m. and at the time of the minimum. These are estimated velocities their absolute values may be somewhat erroneous, but they will nevertheless serve to designate the relative windiness of the different nights. The next column gives the character of the sky at the time of the minimum; the adjectives used are cloudless, thin haze, haze, thinly overcast, overcast. The next column gives the depth of the snow on the ground in inches; it will be seen that all the observations were taken over a snow surface, thus affording absolute uniformity as regards the radiating surface. The last column gives additional facts which may be of interest. Whenever

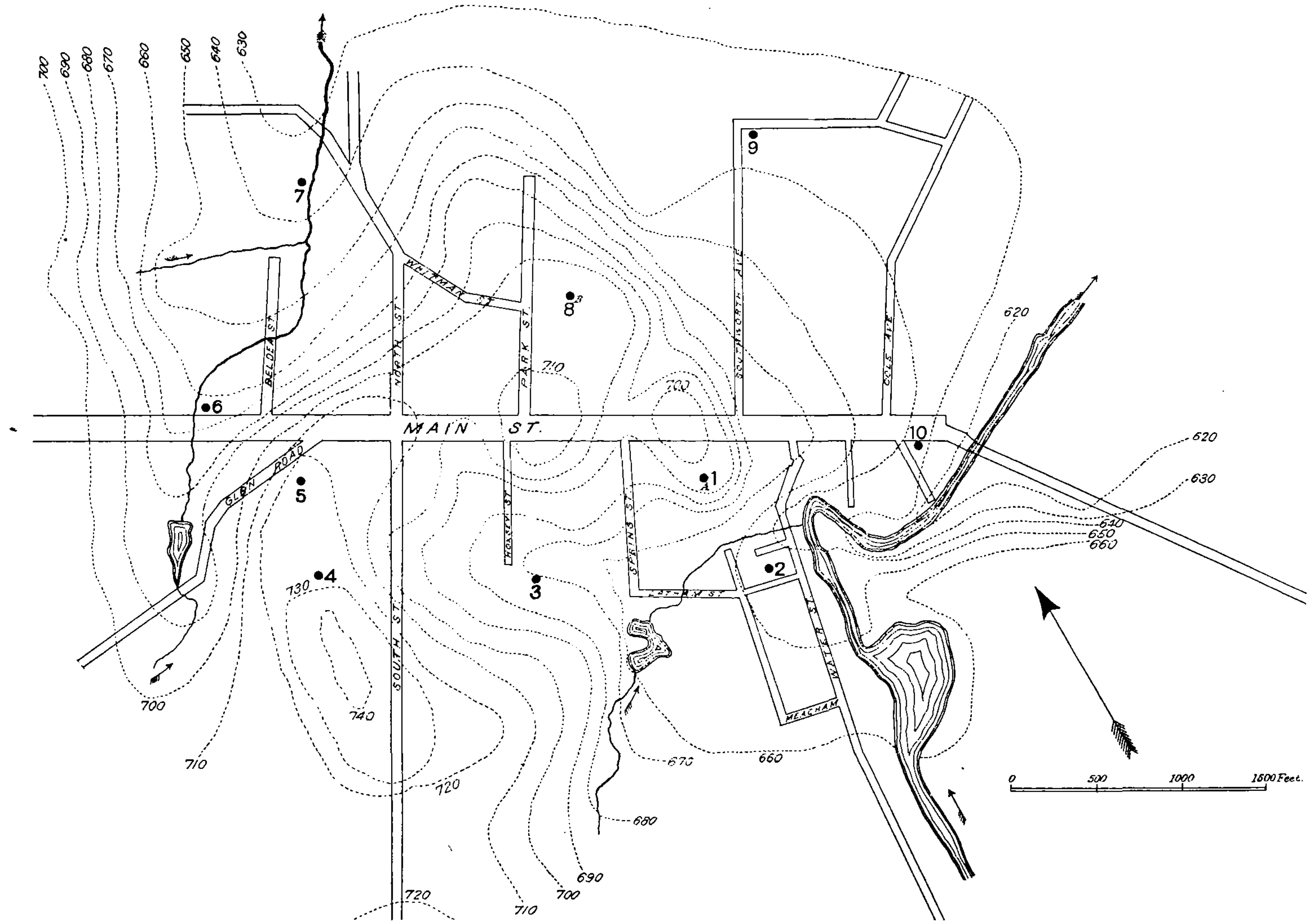


FIG. 1.—Contour lines of the village of Williamstown, Mass.

the minimum did not occur at sunrise or just before, the exact time of the minimum is given in this column.

As a result of these observations the following conclusions may be drawn:

I. AMOUNT OF THE TOTAL VARIATION.

The total variation for each night is found by subtracting the lowest value of minimum temperature observed at any station from the highest value. The 36 values of total variation all fall between the limiting values of 1.0° and 10.0° and the average is 5.1°. An inspection of the 36 values also shows that there is practically no bunching in the neighborhood of the mean value of 5.1°, but that the distribution is fairly uniform between the limiting values of 1.0° and 10.0°.

II. THE INFLUENCES WHICH DETERMINE THE AMOUNT OF THE TOTAL VARIATION.

(1) *Wind.*—The largest value of estimated wind velocity, twelve miles per hour, at the time of the minimum, occurred on January 26, and it will be noticed that the smallest value of total variation, namely 1.0°, was also observed on that date. The three next largest values of estimated wind velocity at the time of the minimum, namely, ten miles on January 4, six miles on February 3, and four miles on February 19, had corresponding total variations of 2.2°, 2.0°, and 2.2°, respectively. These values are far below the average value of total variation, namely, 5.1°. The theoretical expectation that wind would thoroughly mix the lower layers of the atmosphere and render the temperature at different localities fairly uniform is thus verified by the observations. The fact that the readings of all the thermometers are so nearly the same during a wind could also be used as an argument for the accuracy of the thermometers and the uniformity of their exposure.

(2) *The type of night.*—The largest value of total variation, namely, 10.0°, occurred on January 23. There were six inches of snow on the ground at the time, part of it newly fallen. At 10:30 p. m. the wind was blowing gently from the northwest and the sky was cloudless. The minimum occurred just before sunrise and at that time it was absolutely still and there was not a particle of haze or cloud of any kind. The next five largest values of total variation, namely, 9.0° on December 15, 8.0° on December 19, 9.0° on December 22, 7.5° on February 12, and 8.0° on February 15, all occurred on nights of the same type, but entirely different from the one just described. In these cases the wind blew gently from the northwest in the early evening, but soon died down and became calm. The wind then changed to the east or southeast during the night. The minimum always occurred early—as will be seen from the observations between 10 p. m. and 4 a. m. On these nights the sky was hazy or overcast at the time of the minimum. Often in the early morning the sky was entirely covered with clouds, the wind strongly from the east or southeast, and a rise of 20° in temperature; precipitation sometimes followed before noon. It would seem that the coming east wind, either by transportation or mixture, replaced the cooling air of the more exposed or elevated stations with warmer air, thus preventing a drop in temperature while the air in the valleys and less exposed places was allowed to

TABLE 1.—*Record of observations of minimum thermometers at Williamstown, Mass.*

| Date. | Station. | | | | | | | | | | | | Total variation. | Wind. | Character of the sky at time of minimum. | Snow. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | B | | | | | |
| December 10 | 0.5 | ...... | −7.0 | ...... | −3.4 | ...... | ...... | −8.0 | −3.0 | −4.5 | −3.0 | 1.0 | 5.0 | nw., 4–0 | Overcast | 2 | |
| 11 | −3.0 | ...... | −7.5 | −7.2 | −7.9 | ...... | −7.5 | −7.0 | −7.0 | −6.0 | −6.0 | −3.0 | 1.9 | nw., 3–0 | Cloudless | 2 | |
| 12 | −1.0 | ...... | −5.2 | −6.0 | −3.9 | ...... | −4.8 | −6.5 | −3.8 | −4.0 | −2.0 | 1.0 | 4.5 | *nw., 4–0 | Overcast | 2 | Minimum 2 a. m. |
| 14 | 4.0 | ...... | 1.0 | 0.8 | −1.0 | −1.0 | 1.8 | 0.0 | 2.0 | 2.0 | 2.8 | 3.5 | 3.8 | nw., 3–0 | Overcast | 5 | New snow. |
| 15 | −1.6 | −6.0 | −10.5 | −9.6 | −7.8 | −7.0 | −9.0 | −14.0 | −5.0 | −7.2 | −7.0 | 0.0 | 9.0 | *nw., 3–0 | Overcast | 5 | Minimum 11 p.m. |
| 19 | 1.0 | −3.0 | −8.0 | −6.7 | −3.4 | −4.0 | −6.1 | −10.0 | −2.0 | −5.5 | −3.5 | 1.0 | 8.0 | *nw., 1–0 | Haze | 5 | Minimum 3 a. m. |
| 22 | 9.8 | 2.0 | 3.4 | 4.0 | 2.0 | 3.0 | −1.8 | −4.0 | 5.0 | 2.0 | 3.0 | 9.0 | 9.0 | *nw., 15–0 | Overcast | 6 | Minimum 2 a. m. |
| 25 | 0.0 | −1.8 | −2.0 | −2.8 | −2.9 | −2.5 | −2.8 | −3.0 | −1.5 | −2.0 | −1.1 | 0.8 | 1.9 | nw., 2–1 | Cloudless | 1 | Snow dirty. |
| January 4 | 0.0 | ...... | −3.0 | −2.2 | −1.8 | −2.0 | −1.0 | −3.0 | −1.0 | −1.0 | −0.8 | 2.2 | 2.2 | nw., 15–10 | Overcast | 11 | New snow. |
| 5 | −6.0 | −9.8 | −14.0 | −12.0 | −12.9 | −12.0 | −13.0 | −14.0 | −10.0 | −11.5 | −10.5 | −6.0 | 4.2 | nw., 3–1 | Thinly overcast. | 11 | |
| 11 | 10.0 | ...... | 3.0 | ...... | 5.0 | 4.0 | 3.0 | 1.0 | 8.0 | 5.0 | 6.5 | 10.0 | 7.0 | nw., 3–2 | Haze | 11 | Wind gusty. |
| 15 | −1.0 | −4.0 | −4.5 | −5.5 | −6.0 | −6.5 | −5.2 | −7.0 | −4.0 | −3.5 | −3.5 | 0.0 | 3.5 | nw., 6–0 | Thin haze | 6 | |
| 23 | 4.0 | −1.0 | −7.5 | −5.0 | −4.5 | −3.7 | −7.5 | −11.0 | −1.0 | −8.0 | −4.2 | 3.0 | 10.0 | nw., 4–0 | Cloudless | 6 | New snow. |
| 24 | −8.0 | −13.0 | −16.0 | −15.9 | −13.0 | −14.0 | −14.0 | −16.5 | −12.0 | −14.0 | −12.0 | −7.0 | 4.5 | *nw., 2–0 | Thin haze | 6 | |
| 26 | −3.6 | ...... | −4.8 | ...... | −5.0 | −5.5 | −5.0 | −5.0 | −5.0 | ...... | −4.5 | −2.0 | 1.0 | nw., 20–12 | Cloudless | 7 | |
| 27 | −3.0 | −5.8 | −9.0 | −9.5 | −8.0 | −8.8 | −10.0 | −11.0 | −7.0 | −5.0 | −6.2 | −2.0 | 6.0 | *nw., 2–0 | Overcast | 6 | Minimum 11 p.m. |
| 29 | 7.0 | 5.2 | 2.0 | 2.5 | 4.5 | 2.0 | −0.1 | −1.5 | 3.5 | 1.8 | 2.5 | 8.0 | 6.7 | nw., 7–1 | Thinly overcast. | 6 | |
| 30 | 5.0 | 2.5 | 0.0 | 0.0 | 1.0 | 0.5 | −1.0 | −2.5 | 3.0 | 3.8 | 2.8 | 6.0 | 6.3 | *nw., 4–0 | Overcast | 5 | |
| 31 | −6.5 | −10.6 | −12.0 | −12.5 | −11.8 | −12.0 | −13.0 | −14.0 | −10.0 | −11.2 | −10.0 | −5.5 | 4.0 | nw., 1–0 | Overcast | 5 | |
| February 1 | −1.5 | −4.2 | −7.0 | −7.0 | −5.5 | −6.5 | −8.0 | −9.0 | −3.5 | −4.5 | −4.5 | 0.0 | 5.5 | nw., 3–0 | Cloudless | 5 | |
| 3 | 0.0 | ...... | −2.0 | ...... | −2.0 | −3.0 | −2.0 | −2.0 | −2.0 | −1.0 | −1.5 | 1.0 | 2.0 | nw., 25–6 | Cloudless | 5 | |
| 4 | −5.0 | −8.5 | −9.5 | −11.0 | −11.0 | −11.0 | −13.0 | −13.0 | −8.0 | −7.8 | −8.0 | −4.0 | 5.2 | nw., 6–1 | Cloudless | 5 | |
| 5 | −8.0 | ...... | −13.5 | ...... | −14.0 | −15.0 | −15.8 | −16.0 | −10.5 | −12.0 | −11.0 | −6.0 | 5.5 | nw., 6–0 | Cloudless | 5 | |
| 8 | −3.0 | −5.5 | −9.8 | −9.0 | −7.9 | −7.5 | −12.3 | −12.0 | −6.0 | −8.0 | −6.8 | −1.0 | 6.8 | *nw., 12–0 | Cloudless | 6 | New snow. |
| 12 | −5.0 | −8.9 | −12.0 | −11.0 | −9.6 | −9.8 | −12.0 | −15.5 | −8.0 | −9.5 | −8.5 | −4.0 | 7.5 | *nw., 3–0 | Overcast | 6 | Minimum 4 a. m. |
| 14 | −1.0 | −4.5 | −7.2 | −7.5 | −5.5 | −6.5 | −7.0 | −10.0 | −5.0 | −3.6 | −4.0 | 0.0 | 6.4 | nw., 10–2 | Cloudless | 10 | New snow. |
| 15 | 5.5 | 3.5 | −1.0 | ...... | 0.2 | −2.0 | −4.5 | ...... | 0.0 | −2.5 | −0.2 | 3.0 | 8.0 | *nw., 0–0 | Overcast | 10 | Minimum 10 p.m. |
| 16 | −4.0 | −8.0 | −10.5 | −9.5 | −10.0 | −10.2 | −13.5 | −14.0 | −8.7 | −9.0 | −8.5 | −3.0 | 6.0 | nw., 9–1 | Cloudless | 11 | New snow. |
| 19 | 2.0 | −1.0 | −3.0 | ...... | −0.8 | −2.8 | −3.0 | −3.0 | −1.2 | −2.5 | −1.8 | 2.0 | 2.2 | nw., 15–4 | Cloudless | 12 | Wind gusty. |
| 25 | 3.5 | ...... | −4.0 | 0.0 | −1.0 | −1.5 | −2.0 | −5.5 | 0.9 | −1.5 | 0.0 | 5.5 | 6.4 | nw., 3–1 | Cloudless | 7 | Old snow. |
| 28 | 11.0 | 7.8 | 5.0 | 5.0 | 6.0 | ...... | 6.0 | 2.5 | 7.5 | 7.0 | 7.0 | 11.0 | 5.3 | *nw., 4–1 | Overcast | 6 | Minimum 3 a. m. |
| March 1 | 4.0 | ...... | −2.2 | −2.0 | 0.5 | −1.5 | −0.5 | −2.5 | 2.0 | 1.0 | 1.5 | 6.0 | 4.5 | nw., 4–1 | Cloudless | 6 | |
| 2 | 2.5 | −2.0 | −5.0 | ...... | −3.0 | −4.0 | −5.0 | −8.0 | −2.0 | −3.5 | −2.0 | 3.0 | 6.0 | nw., 3–0 | Cloudless | 6 | |
| 3 | 4.0 | 0.0 | −3.2 | ...... | −0.5 | −1.5 | −2.5 | −6.0 | 0.2 | −1.2 | 0.0 | 5.0 | 6.2 | nw., 2–0 | Overcast | 6 | |
| 5 | 1.5 | −3.0 | −6.5 | −7.0 | −4.1 | −5.0 | −6.8 | −9.0 | −2.5 | −4.5 | −3.8 | 2.0 | 6.5 | nw., 2–0 | Overcast | 6 | |
| 7 | 2.5 | −0.8 | −4.0 | −4.0 | −2.0 | −3.5 | −3.0 | −5.0 | −0.5 | −0.5 | 0.0 | 3.0 | 5.0 | *nw., 1–0 | Cloudless | 6 | Snow very dirty. |
| Average | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 5.1 | ...... | ...... | ...... | |
| Average variation as compared with station 8 | 3.2 | −0.7 | −2.7 | −2.5 | −1.5 | −2.2 | −3.2 | −4.8 | 0.0 | −1.1 | −0.3 | 3.9 | ...... | ...... | ...... | ...... | |
| Limits of the variation | 1.0 to 4.8 | 3.0 to −3.5 | 0.2 to −6.5 | −0.2 to −4.7 | 1.0 to −3.5 | −0.5 to −4.5 | 0.0 to −6.8 | 0.0 to −10.0 | ...... to ...... | 2.0 to −7.0 | 1.8 to −3.2 | 1.5 to 5.0 | ...... | ...... | ...... | ...... | |
| Elevation of station, feet | ...... | 698 | 648 | 672 | 723 | 725 | 662 | 635 | 701 | 634 | 633 | ...... | ...... | ...... | ...... | ...... | |

remain and become cold by radiation and conduction. This would explain the large total variations on this type of night.

(3) *The existing temperature.*—The average value of total variation on the ten coldest nights at station 8 is 5.2° with an average temperature of 8.7° below zero, while the average value of total variation on the ten warmest nights is 6.3° with an average temperature of 3.2°. It thus seems safe to draw the conclusion that the amount of total variation does not depend markedly on the coldness of the night, and certainly does not become greater the colder the night. And this is what one would theoretically expect, for radiation is the only element producing the variation which can depend on the coldness of the night, and here we have to do with only the relative radiation of the different stations. These influences may be summarized as follows: The amount of the variation is much less on a windy night, is not influenced by the coldness of the night, and is greatest on the two types of nights described above.

### III. CORRELATION OF VARIATION AND LOCALITY.

Thus far the amount of the total variation, and the conditions that influenced it, have been treated without considering which station happened to be the coldest and which the warmest. The next natural question is this: Are certain stations always the colder ones while others are always above the average? If this definite distribution of the larger and smaller values of minimum temperature among the stations does exist, what is its cause? There are three ways by which an idea of the definiteness of this distribution can be obtained.

(*a*) First from the statistics given in the last three rows of of the table of observations. Station 8 was taken as the one with which to compare the others, as it happened to be the warmest station. It will be noticed in the case of station 1, for example, that it averaged 0.7° colder than station 8, but varied on different nights all the way from 3.0° warmer to 3.5° colder. Station 7, however, averages 4.8° colder than station 8, and varies all the way from being as warm to 10.0° colder. This station was never warmer than station 8. The corresponding facts are given in the table for the other stations.

(*b*) The following summary furnishes a second way of forming a picture of the definiteness of the distribution. During the 36 nights on which observations were recorded, the following stations were warmest or coldest by the indicated number of times. When two or more stations had the same temperature and were either warmest or coldest it is noted as warmest or coldest for each of them:

| Warmest station. | | Coldest station. | |
|---|---|---|---|
| Station 8 | 16 times. | Station 7 | 30 times. |
| Station 10 | 12 times. | Station 6 | 4 times, |
| Station 1 | 8 times. | Station 5 | 3 times. |
| Station 9 | 7 times. | Station 2 | 3 times. |
| Station 4 | 1 time. | Station 4 | 2 times. |

(*c*) Thirdly, by following down two columns of observations in the table of observations (those for stations 7 and 8 are particularly well suited) it can not fail to be noticed with what regularity one of the stations is colder than the other.

A summary of the observations carried on during a single winter is thus sufficient to locate each station definitely in a scale of relative coldness, but the distribution of minimum temperatures is not so definite that observations for one or two nights would be sufficient to determine the relative coldness of a number of stations in an unknown locality. It is natural to think of elevation as the chief cause of the variation in minimum temperatures. When the air temperature at a station changes during the night it is the result of radiation and conduction, or transportation, or both. If the wind is blowing, then warmer air from high altitudes (an inversion of temperature is here assumed) or other localities, or colder air from some other locality, may be mixed with or even replace the air at some particular station. If the wind is not blowing, there would still be the natural drainage of colder, and thus denser air into the valleys from places of greater elevation. Thus, not only elevation, but also the openness of a valley, its direction, the roughness of the surface, and the direction from which the wind comes, would play a part in determining the minimum temperature. When we turn to the observations it will be seen that in fact elevation does play an important part. The valley on the west side of the village is well marked and the steady increase of coldness from station 4, past stations 5 and 6, westward to station 7 is very pronounced in the table of observations. The same thing is well marked between stations 7 and 8 and also between stations 1 and 2. On the other hand stations 8 and 9 and also stations 1 and 10 are practically of the same coldness although there is a marked difference in elevation. It will be seen from the elevations given in the table of observations that the highest station is not the warmest and the lowest station is not the coldest. The conclusion which must be drawn is this: Elevation plays an important part, but it must by no means be stated that stations can be arranged in order of coldness depending upon their elevation alone.

IV. THE EFFECT OF A THERMOMETER SHELTER.

The observations recorded in the column "A" were the readings of the registering, minimum thermometer in the thermometer shelter. They average 3.2° warmer than station 8, while station 1 averages 0.7° colder. This makes the readings at station A average 3.9° warmer than station 1. A direct comparison of the observations made at stations A and 1 for the nights when both were recorded makes A 3.7° warmer than station 1, with 1.8° and 7.8° as the limits in the variation. This means that during the still, clear winter nights a registering minimum thermometer exposed in the standard thermometer shelter reads on the average between 3° and 4° higher than the same instrument exposed in the open.

V. EFFECT OF A PIAZZA.

The column headed "B" contains the observations made on the piazza of a house twenty feet southeast of station 8. The readings average 3.9° warmer than station 8, with 1.5° and 5.0° as the limits of the variation. It will thus be seen that even on the post of a north piazza, a thermometer may read nearly 4° too high on still, clear winter nights.

This investigation might be extended in two directions. The given observations were all made while the ground was covered with snow. A similar series made during the summer when the ground is covered with vegetation would give an interesting comparison.

Station 8 has been found to be the warmest while station 7 is the coldest. By placing a number of thermometers between these two stations and taking readings every hour or every two hours during certain nights in winter interesting results might be obtained as to the relative importance of conduction and radiation and transportation of air in determining the temperature.

## EARTHQUAKES RECENTLY RECORDED AT THE WEATHER BUREAU.

By C. F. MARVIN, Professor of Meteorology. Dated August 7, 1905.

Several distant earthquakes have recently been registered at the Weather Bureau, one of which was by far the most important lately experienced. No motion was felt on this occasion by any individuals so far as known; in fact the curious thing is that no accounts of any great earthquake or other disturbance that could produce the records we find have been reported in the public press anywhere. Reports from distant observatories at which seismographs are maintained are not available at the present time, but there is no doubt that the disturbance was registered all over the world.

The displacements shown by the Bosch-Omori seismographs at Washington were several times greater and many times more numerous than in the case of the great Indian earthquake of April 4. Other cases have likewise occurred in which great unfelt disturbances have been registered seemingly unaccompanied at any known or inhabited portion of the globe with such surface disasters as we are led to look for or as seem to be required to explain the occurrence of our records. Even where earthquakes occur deep under the sea, at great distances from land, we expect them to be accompanied by tidal waves of greater or less magnitude as tangible evidence of their occurrence. When, therefore, we find large disturbances recorded without being able to trace them to any obvious cause the question may be asked: Can the origin of these great effects possibly be so deep seated within the earth that the waves reaching the surface are not only feeble, but are not even of the same character as those we feel and that destroy buildings, etc. The suspicion may be awakened in the minds of some not familiar with the maintenance of modern seismographs that the records are not genuine, or may be due to some accidental local causes. This can not possibly be the case. No human, nor accidental, nor artificial agency can possibly produce one of these records *de novo* in all its minute perfection. It may be copied and duplicated, or possibly imitated if an elaborate machine were constructed for the purpose, but nothing but real motions in the crust of the earth can cause the instrument itself to produce such original records as these.

This last great disturbance began at Washington at $10^h$ $10^m$ $13^s$ p. m., of July 22, seventy-fifth meridian time, and from that time on for more than two hours and a half perceptible movements of the earth crust were being registered. For a period of nearly twenty-three minutes, from 10:30 to 10:53 p. m., the motions, especially in the east and west directions, were unusually great, the maximum wave to the west measuring 5.4 millimeters, while the pen went off the sheet three times in the east direction, which required a movement of more than 5 millimeters.

The entire records for this earthquake are shown on Plate I.

Tables 1, 2, 3, and 4 present the principal characteristics of the several earthquakes registered on the seismograph at the Weather Bureau, Washington, D. C., on seventy-fifth meridian time.

TABLE 1.—*Earthquake of May 9, 1905, N-S. component.*

| | h. | m. | s. |
|---|---|---|---|
| First preliminary tremors began | 2 | 53 | 42 a. m. |
| Principal portion began | 2 | 57 | 32 a. m. |
| Principal portion ended | 2 | 58 | 48 a. m. |
| End of earthquake | 3 | 15 | 52 a. m. |
| Duration of first preliminary tremors | | 3 min. | 50 sec. |
| Duration of principal portion | | 1 " | 16 " |
| Total duration of earthquake | | 22 " | 10 " |
| Period of pendulum | | | 28 sec. |
| Maximum double amplitude of actual displacement of the earth at the seismograph | | | 0.1 mm. |
| Magnification of record | | | 10 times. |

This earthquake was too small and feeble to fully develop all the usual characteristics of such records.

TABLE 2.—*Earthquake of July 9, 1905, N-S. component.*

| | h. | m. | s. |
|---|---|---|---|
| First preliminary tremors began | 5 | 4 | 35 a. m. |
| Second preliminary tremors began | 5 | 22 | 7 a. m. |
| Principal portion began | 5 | 33 | 42 a. m. |
| Principal portion ended (not well defined) | 5 | 46 | 27 a. m. |
| End of earthquake | 6 | 34 | 25 a. m. |
| Large waves in second preliminary tremors | 5 | 30 | 7 a. m. |